DIGITAL EQUIPMENT CORPORATION
education

Computers Are For Kids, Not For Geniuses

Computers Are Here to Stay

The twenty-five centuries that lie between us and Socrates have added an immense amount of wisdom and knowledge to the cultural fund of humanity. Instead of being its slave, seeing himself surrounded by magic forces, man has become the master of his physical environment, or nearly so. The same trend away from dependence toward systematic understanding of man and his environment has also brought about new concepts of the role of education. With the advent of the first practical electronic computer twenty years ago, man found himself able to reach out and explore previously inaccessable areas of knowledge. In turn, man has pushed the horizons of knowledge outward at an ever-increasing rate until today we find the computer an indispensible tool which touches on virtually every aspect of our lives.

Today's computers, smaller, yet more powerful and easy to live with than their predecessors, aid engineering design, launch and control guided missiles, control inventories, and make up payrolls. Today's computers don't require a degree in computer science to use them. They are being used as tools in the fields of weather prediction, newspaper typesetting, patient monitoring in hospitals, and in the analysis of all phases of business, social, linguistic and historical information.

A Computer for Student Instruction

As it has become easier and more natural to use, the computer has become an effective partner to all aspects of learning. Integrated into a school's present math and science curriculum, it is a motivational and reinforcement tool of proven power. Used with imagination, it enables students and scholars to deal with realistic problems rather than oversimplified models. Not only does the computer allow students to do ordinary tasks more easily, it also opens the door to projects and experiments, which would be impossible using hand calculations. The computer is becoming indispensible in so many fields of endeavor, that no matter what his specialty, students and teachers must learn how to comfortably use the computer and tap its vast potential.

High schools, colleges, and universities are already expanding their existing computer facilities, and developing new ones where none exist, in order to provide students with this opportunity. Educators at these schools describe the computer as "a powerful aid to learning" and "a wonderful motivational tool". But such testimonials are not by themselves justification for adding a computer to the resources of your school.

What does justify such an investment are the results which these schools are getting from their computer. The computer's ability to dramatically improve the learning process has been proven in school after school. Not just among the brightest students, not just in the math classes, but wherever the computer is applied.

The computer does not replace the teacher. Nor does the simple existence of the computer make a poor student into a superior student. But in school after school, the computer is turning the bored, lethargic student into an involved, eager student. A computer can, and has, turned course X from "dullsville" to "my favorite subject". And as any educator knows, this is the vital, first step to better education.

The Computer Deepens Understanding

Experience has shown that the computer may be applied effectively to nearly any subject on virtually any level. It is capable of doing very sophisticated tasks indeed. But the following familiar problem, appropriate for an average student in a first-year algebra course, is typical of what the role of the computer can be.

> *The Problem:* Two pipes lead into an irrigation storage reservoir. Pipe A can fill the reservoir in 15 hours, while Pipe B can fill it in 18 hours. Pipe B may also be alternatively used as an outlet for irrigating the land.
>
> 1. How long will it take to fill the reservoir if Pipes A and B are flowing in at the same time?
>
> 2. How long will it take to fill the reservoir if Pipe A is flowing in and Pipe B is irrigating the land?
>
> *Step #1*—The student must reason that this is an algebra problem using fractional equations. He recalls that if t is the time required for a pipe to fill the reservoir, then 1/t is the part of full capacity that pipe can fill in an hour. If he lets x be the time required to fill the reservoir using two pipes, then:
>
> $$\frac{1}{X}=\frac{1}{A}+\frac{1}{B} \text{ and } x=\frac{1}{\frac{1}{A}+\frac{1}{B}}$$
>
> Of course, if Pipe B is flowing out, then B is negative. If he doesn't know the proper algorithm, he is stuck; he must have learned and understand the principle.

Step #2—The student sets up his program to use the algorithm properly. He does this using a "flow chart" which breaks the problem down into steps (Figure 1). This process imposes the need for rigorous thinking and expression which is, of course, a most important part of the learning process.

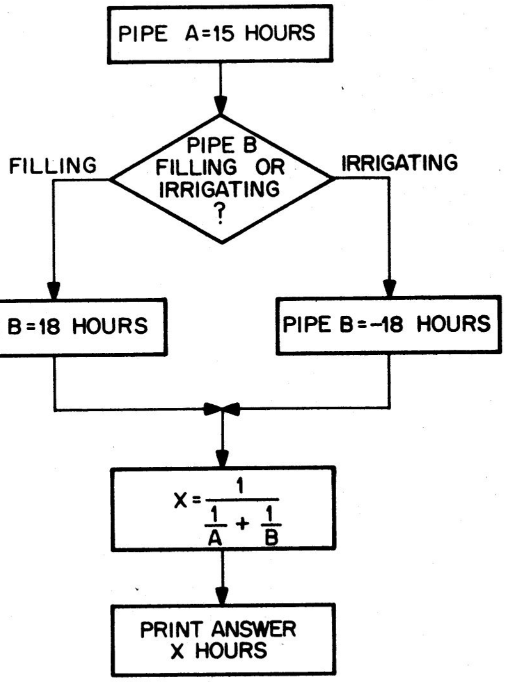

Figure 1 IRRIGATION PROBLEM FLOW CHART

Step #3—Using his flow chart, the student writes a program to solve his problem. This is written in a very simple, natural language which corresponds to his flow chart (Figure 2).

```
.R BASIC

NEW OR OLD--NEW
NEW PROGRAM NAME--IRRGN

READY

10 LET A=15
20 LET B=18
30 PRINT "TYPE 1 IF PIPE B FILLS,"
35 PRINT "TYPE -1 IF IT IRRIGATES"
40 INPUT P
50 LET B=B*P
60 LET X=1/(1/A+1/B)
70 PRINT X "HOURS"
80 END
```

Figure 2 IRRIGATION PROBLEM PROGRAM

Step #4—The student enters his program into the computer. In effect, he is teaching the computer to solve the problem. To do so successfully, he must thoroughly understand it himself. If he does, and he has taught the computer properly, i.e., he has written the problem accurately, the computer responds with the right answer (Figure 3). It does all the calculations, no matter how messy they are. There is no need to set up problems so they "come out even". And right or wrong, the student gets the result (and the reinforcement) immediately.

```
READY

RUN

TYPE 1 IF PIPE B FILLS,
TYPE -1 IF IT IRRIGATES
? 1
 8.181818 HOURS

READY

RUN

TYPE 1 IF PIPE B FILLS,
TYPE -1 IF IT IRRIGATES
? -1
 90 HOURS

READY

BYE
```

Figure 3 IRRIGATION PROBLEM PROGRAM EXECUTION

P.S. If this had been a normal pencil and paper assignment, the student's thinking would have ended when the answer was obtained. When a computer is involved, this is rarely the case. The student is eager to go on. He may notice that he can set A and B to any value and the program is valid for any pipe sizes. (Oops! Almost valid. What happens if the drain pipe works faster than the fill pipe? Better add a statement to the program to check for this.) Many students will be motivated to make their program work for different numbers of pipes. In short, they start asking "What if"? What if I made a pipe B twice as big, would the reservoir fill twice as fast? What if a second fill pipe was added? The computer supplies the answers to these questions immediately. And throughout the process the student is working with the fundamental concepts *and* gaining confidence in his understanding of the algorithm *and* having fun doing it. That's how the computer deepens understanding.

The Computer Reinforces and Motivates

The computer is an exciting contemporary piece of equipment. This fact alone explains some of the fascination that a computer invariably stirs up among students. But it doesn't explain all of it. The powerful motivational capabilities which the computer demonstrates in every school which installs one can only be explained by the way it is used.

The computer is tireless. Unlike a student, it loves to do complex calculations. Separating theory from calculation in school assignments has always been a problem. Some of the most interesting and challenging concepts of math and science involve, unfortunately, an overwhelming amount of dull calculations. The student gets bogged down in the arithmetic and never gets excited about the idea. Or worse still, a less important concept is taught instead, just because its calculations "come out even". The computer, by taking on all calculations and doing them quickly and accurately, opens up new possibilities for classroom study and student interest.

The computer is immediate and unfailingly accurate. It does in seconds what people take minutes or hours to do. The speed of its responses make for powerful reinforcement. It challenges the student to think through the concepts as fast as it grinds through the calculations.

The computer provides identity. Students need individual attention yet classes and schools need an identity. Classes can't function when they're fractionalized. The computer provides a focus around which to build class identity. Virtually every school with a computer has a computer club. And not just for five or six top students. Everyone wants to join. Like ski bums and surf bums, today we have a growing legion of computer bums—with one important difference—the computer bum gains an expanded intellect and broadened curiosity, not just a suntan.

The computer is anonymous. Real learning occurs when a student has an idea and tries it out. At the start, he isn't sure whether it's right or not. Some students have no fear of being wrong. They raise their hand and tell the class their idea. Others are less willing to risk the ridicule of being wrong. The computer lets all students try out their ideas and gain confidence in them. It treats all students alike; it has no favorites. It waits for the slower user; bounds ahead quickly for the brighter student. With a computer, a student competes with his past achievements, not with other students.

Above all else, the computer is challenging. Why is it that a student who quits on a homework problem after trying it once will work tenaciously to get a program running right? Partly, it's the immediacy of the computer's response. Partly, it's the ease with which the student may change his program and try again. Partly, it's the fun of "talking" to a machine and having it respond. But beyond all that, there is something about the close interaction between a user and a fast, willing, logical machine which is tremendously challenging. And not just to students. Teachers get just as involved as their students. If you've used a computer and written a program, you know. If not, Digital can arrange to put you in contact with a low-cost, expandable Digital EduSystem so you can experience first-hand the possibilities of a computer in your school.

The Computer Expands the Classroom

The computer is by no means limited to the math class. Although it often finds its first use in the teaching of algebraic methods and algorithms, the computer can do much, much more. One of its most exciting applications is in doing "simulations". A simulation is a program which models a physical event. For example, a computer program can simulate a lunar module. It has a fixed amount of fuel. By properly adjusting the firing rate of the module's retrorocket, it may be brought in for a soft landing. In this particular simulation, the computer doesn't decide how fast to burn the retro-rocket. The student does. At 10 second intervals the student is asked at what rate he wishes to fire the retro-rocket for the next 10 seconds. The computer uses this firing rate to calculate the new position and speed of the module. At each stage of the descent, the module's situation depends on the previous decisions of the student. Obviously, the student is strongly motivated to land softly and safely. But in order to do so, he must understand the consequences of his decisions. In this case, he must understand Newton's Laws of Gravity. He must then apply them to a topical, contempary situation which he could never experience in real life. The simulation gives the student a powerful impetus toward understanding physics.

In the above example, the simulation could exactly conform to the physical event. This is because the event is precisely describable by mathematical formula (which in itself is an important thing for the student to understand). But a precise mathematical base is not necessary for a useful simulation. In the field of economics, for example, no precise formulae are possible. Nevertheless, there are quantifiable laws, such as supply and demand or scarcity which may be vividly simulated.

A program, for example, can simulate the important facets of a country's economy. In one such program simulating an ancient country, the king decides how much grain will be stored away, how much planted for next year's harvest, how much distributed to his subjects for food, and how much bartered away for more land to expand his kingdom. On the basis of these decisions, plus a random factor which no king, no matter how powerful, can control, subjects may starve, a meager or bountiful amount of grain will be harvested, and, alas, rats or plague may strike. In this simulation, the student at the terminal is King Hamurabi. Once a year, he decides the economic policy of Sumeria for that year. The computer then reports the results of his actions. Events are interrelated. Grain used to feed the population cannot also be used as seed to plant the next year's crop. All the land and grain in the world won't help if the population has starved and no one is around to do the planting. Increasing the amount of grain in storage increases the chance that rats will get at it. In general, a wise policy will result in a flourishing kingdom but greed, or a disastrous plague, are sure to bring hard times. See Figure 4.

Just like being there? No, not quite. But several important sociological, historical and economic principals are brought dramatically to life. The skill and knowledge of the student matter very much. If you have ever used or developed such a simulation (the lunar landing simulation was written by a high school student) you know how it brings the situation to life in a way no textbook can. If you haven't, an economical, easy-to-use Digital Edu-System will let you experience first-hand the many ways that a computer can expand your classroom.

...And Much, Much More

In all these ways, the computer stimulates the student, stretches his thinking, provides an immediate and pertinent application for skills learned in class. It provides a sense of formal methods and their purpose. It gives students a chance to learn to distinguish situations where looser thinking is appropriate. The extension of an operation to a larger domain becomes an everyday activity, in other words, generalization becomes routine for students exposed to a computer.

But the impact on the teacher can be just as great as the impact on the student. Given motivated students, the dedicated teacher becomes even more dedicated. It is by no means unusual for a teacher to have to clear students out of the computer room at 5 o'clock because he has to go home (or so he can work on a program of his own).

The computer also upgrades a school's faculty by attracting better new teachers. The superior teacher, who is qualified to teach in even the best schools, will be drawn first to a school which has a computer which he can use in his teaching. Bright young teachers, who have used computers in colleges, will also be strongly attracted to the school system which is computer-oriented.

Computers have other uses around the school other than instruction. For example, a computer can easily be programmed to grade tests thereby saving precious teacher time, as well as providing more immediate feedback to students. Other tedious, administrative chores can be put on the computer too such as attendance reporting, report cards, transcripts and payroll.

What will the computer mean in your school? Faster learning. Tests have shown that students who use the computer as part of their math class improve at 4 times the rate of those who are taught in the traditional way. Not just honor students. Not using a futuristic curriculum. A cross-section of students—black, white, Mexican, disadvantaged, rich, middle-class—in regular algebra classes improved four times as fast with the computer.

The computer also means more thorough understanding coupled with tremendous student motivation. It means more dedicated teachers and an easing of tedious, administrative chores. It means contemporary education for today's world.

Can you see why we at Digital firmly believe that today computers are for all kids, not for a few geniuses?

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HAMURABI:
I BEG TO REPORT THAT LAST YEAR=      0 DIED OF STARVATION,
=      5 PEOPLE CAME TO THE CITY, AND THE POPULATION IS NOW=    100

THE CITY NOW OWNS=  1000 ACRES OF LAND.

WE HARVESTED=      3 BUSHELS PER ACRE; THE HARVEST WAS=  3000 BUSHELS.
=    200 BUSHELS OF GRAIN WERE DESTROYED BY RATS AND YOU NOW HAVE
=  2800 BUSHELS IN STORE.


DO YOU WISH TO CONTINUE? (ANSWER YES OR NO):YES


HAMURABI:
THIS YEAR LAND MAY BE TRADED FOR=     19 BUSHELS PER ACRE;
HOW MANY ACRES DO YOU WISH TO BUY?
:25
HOW MANY BUSHELS OF GRAIN DO YOU WISH TO DISTRIBUTE AS FOOD?
:1800
HOW MANY ACRES OF LAND DO YOU WISH TO PLANT WITH SEED?
:1000


HAMURABI:
I BEG TO REPORT THAT LAST YEAR=     10 DIED OF STARVATION,
=      3 PEOPLE CAME TO THE CITY, AND THE POPULATION IS NOW=     93

THE CITY NOW OWNS=  1025 ACRES OF LAND.

WE HARVESTED=      4 BUSHELS PER ACRE; THE HARVEST WAS=  4000 BUSHELS.
=      0 BUSHELS OF GRAIN WERE DESTROYED BY RATS AND YOU NOW HAVE
=  4025 BUSHELS IN STORE.


DO YOU WISH TO CONTINUE? (ANSWER YES OR NO):YES


HAMURABI:
THIS YEAR LAND MAY BE TRADED FOR=     21 BUSHELS PER ACRE;
HOW MANY ACRES DO YOU WISH TO BUY?
:0
TO SELL?
:0
HOW MANY BUSHELS OF GRAIN DO YOU WISH TO DISTRIBUTE AS FOOD?
:1900
HOW MANY ACRES OF LAND DO YOU WISH TO PLANT WITH SEED?
:1025


HAMURABI:
 THINK AGAIN. YOU HAVE ONLY=     93 PEOPLE.

HOW MANY ACRES OF LAND DO YOU WISH TO PLANT WITH SEED?
:930
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Figure 4 KING OF SUMERIA SIMULATION SAMPLE OUTPUT

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